Complete dipole response in ^{208}Pb from high-resolution polarized proton scattering at 0°*

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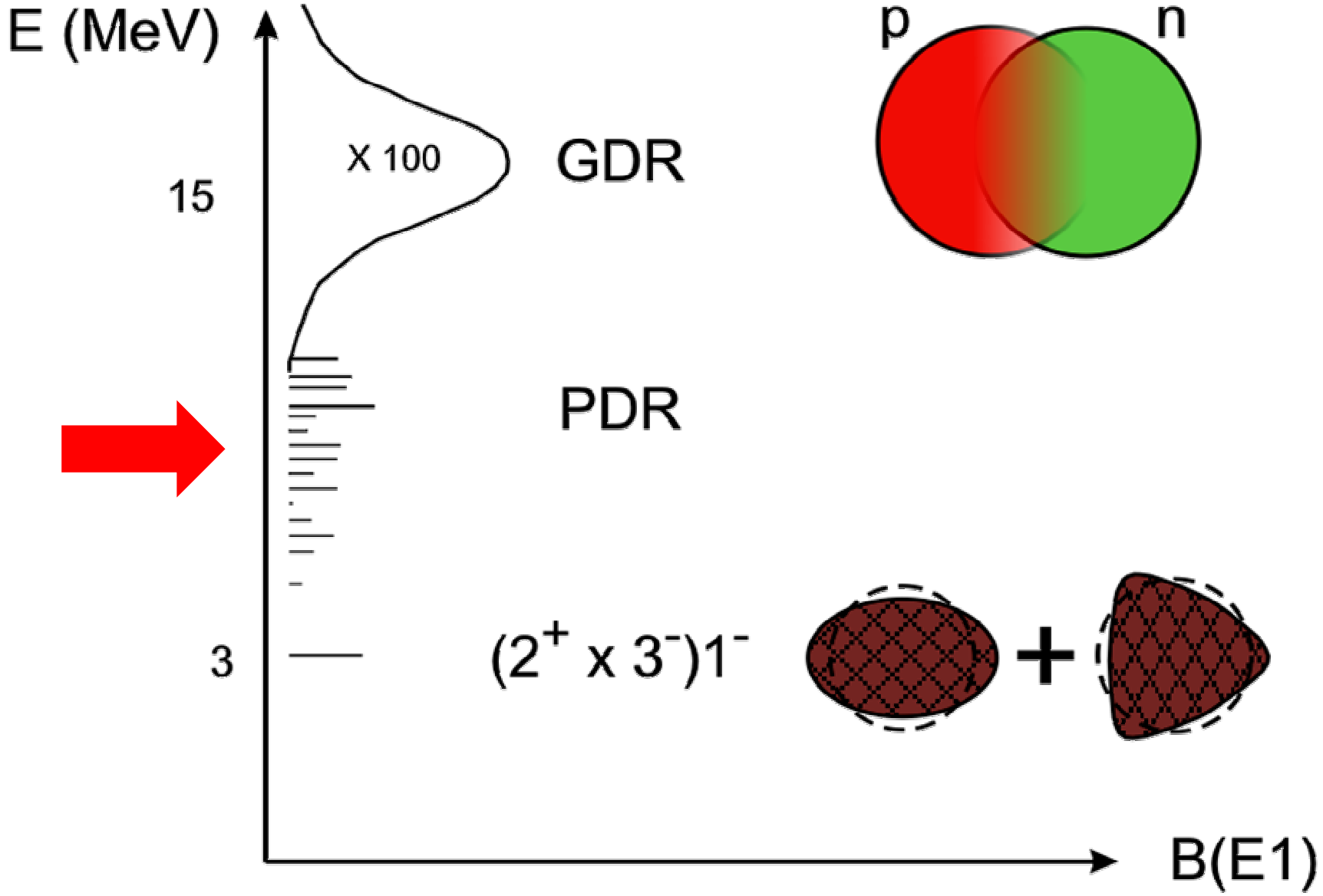
RCNP

- Motivation
- Experimental setup
- Results
  - Coulomb excitation
  - Multipole decomposition
  - Asymmetry
- Summary and outlook

SFB 634

*Supported by the DFG within SFB 634 and 446 JAP 113/267/0-2

B(E1) Strength Distribution



Reminder
The Pygmy Dipole Resonance in ^{208}Pb

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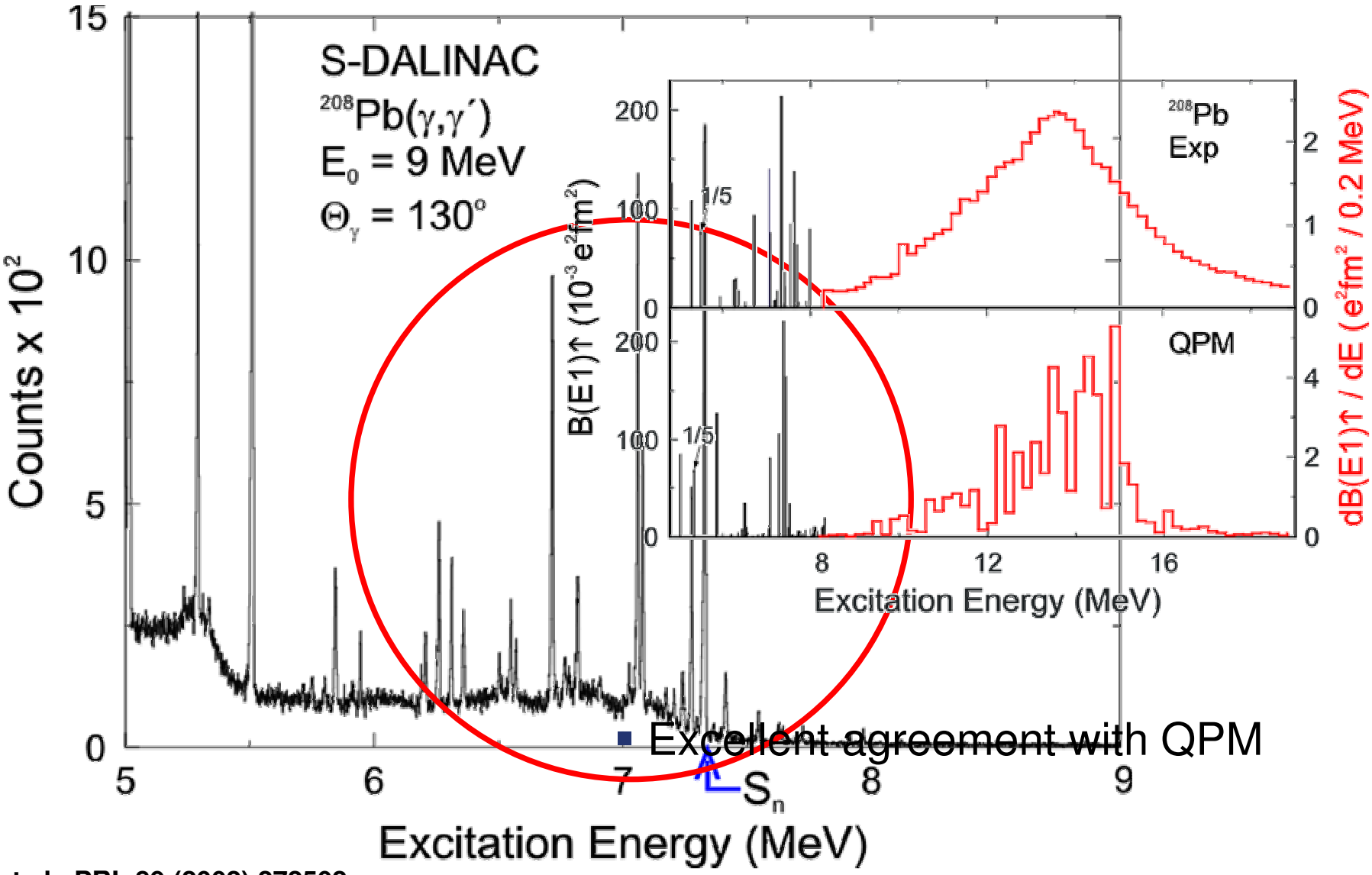
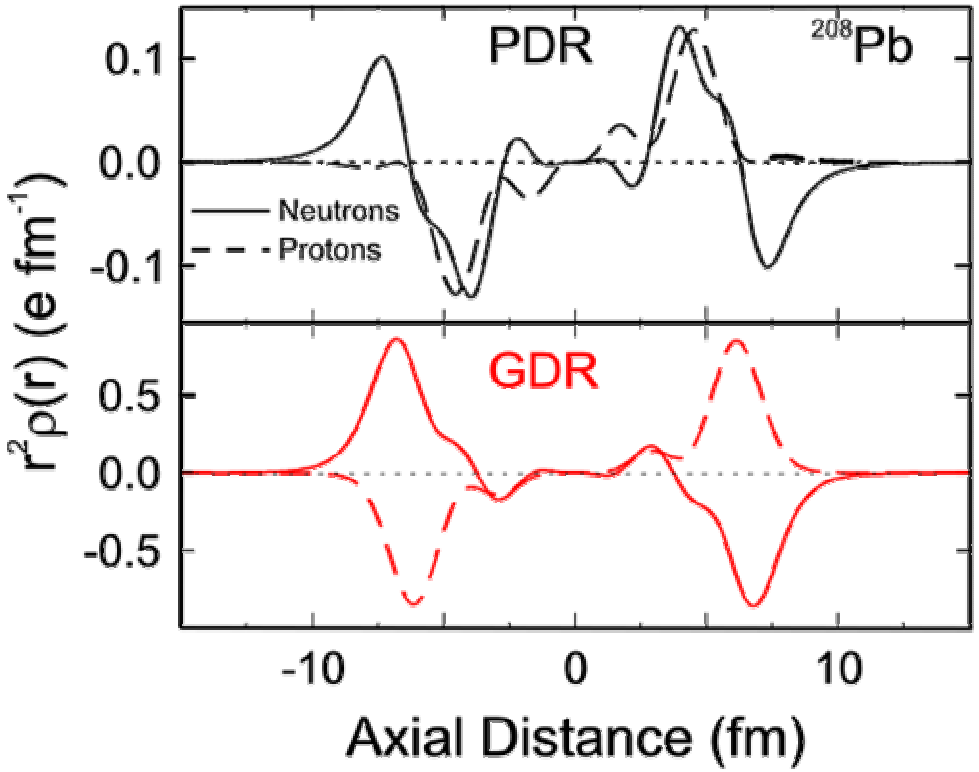
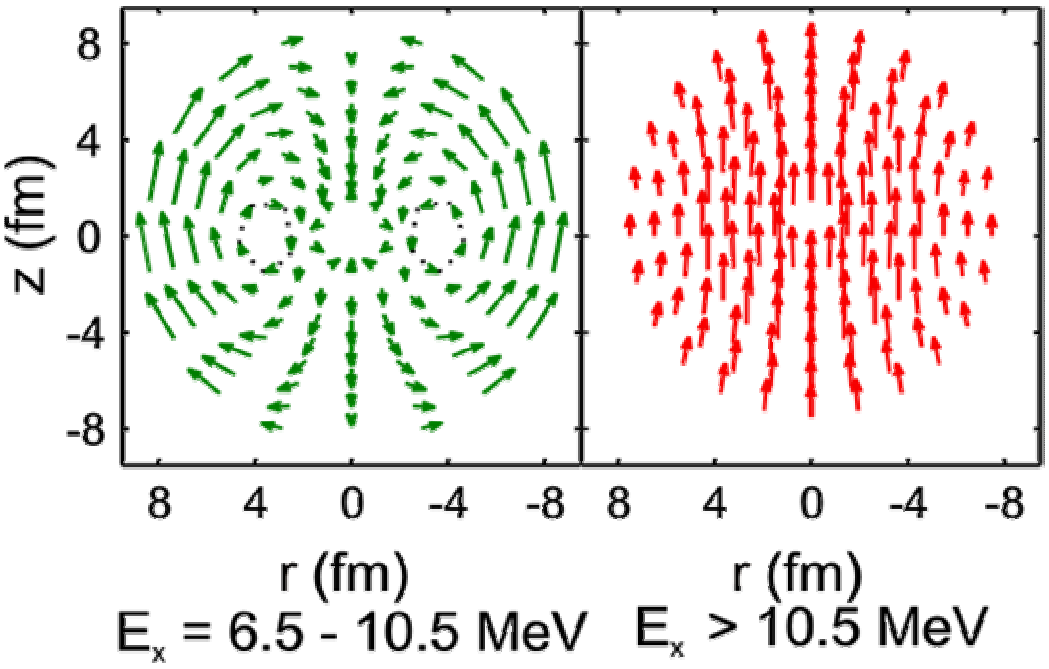


N. Ryezayeva et al., PRL 89 (2002) 272502

Structure of Low-energy E1 Modes





- Oscillations of neutron skin
- Toroidal mode

Elucidation of the Structure of the Low-Energy Modes

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- (e,e´) at backward angles
  - transverse response
  S-DALINAC, TU Darmstadt

- ($\vec{p}$,$\vec{p}$´) at 0°
  - longitudinal response
  (Coulomb excitation)
  - sensitive to polarization observables
  RCNP, Osaka University

Spin M1 Strength in ^{208}Pb

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- Spin-flip M1 resonance is quenched
  - ^{208}Pb as a test case
- Problem studied in the 80's but:
  - large experimental uncertainties
  - improved model calculations
- new experimental access by (p,p´)
  - intermediate energy region optimal for spin-isospin excitations
  - at 0° → selectivity on $\Delta L=0$ transitions
  - isovector spin-flip M1 transitions enhanced
- Overlap with PDR

Polarized Proton Scattering

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- intermediate energy

300 MeV optimal →

- spin-isospin excitations

- angular distributions
  - measurements at 0°
  - measurements at finite angles

Multipole Decomposition →

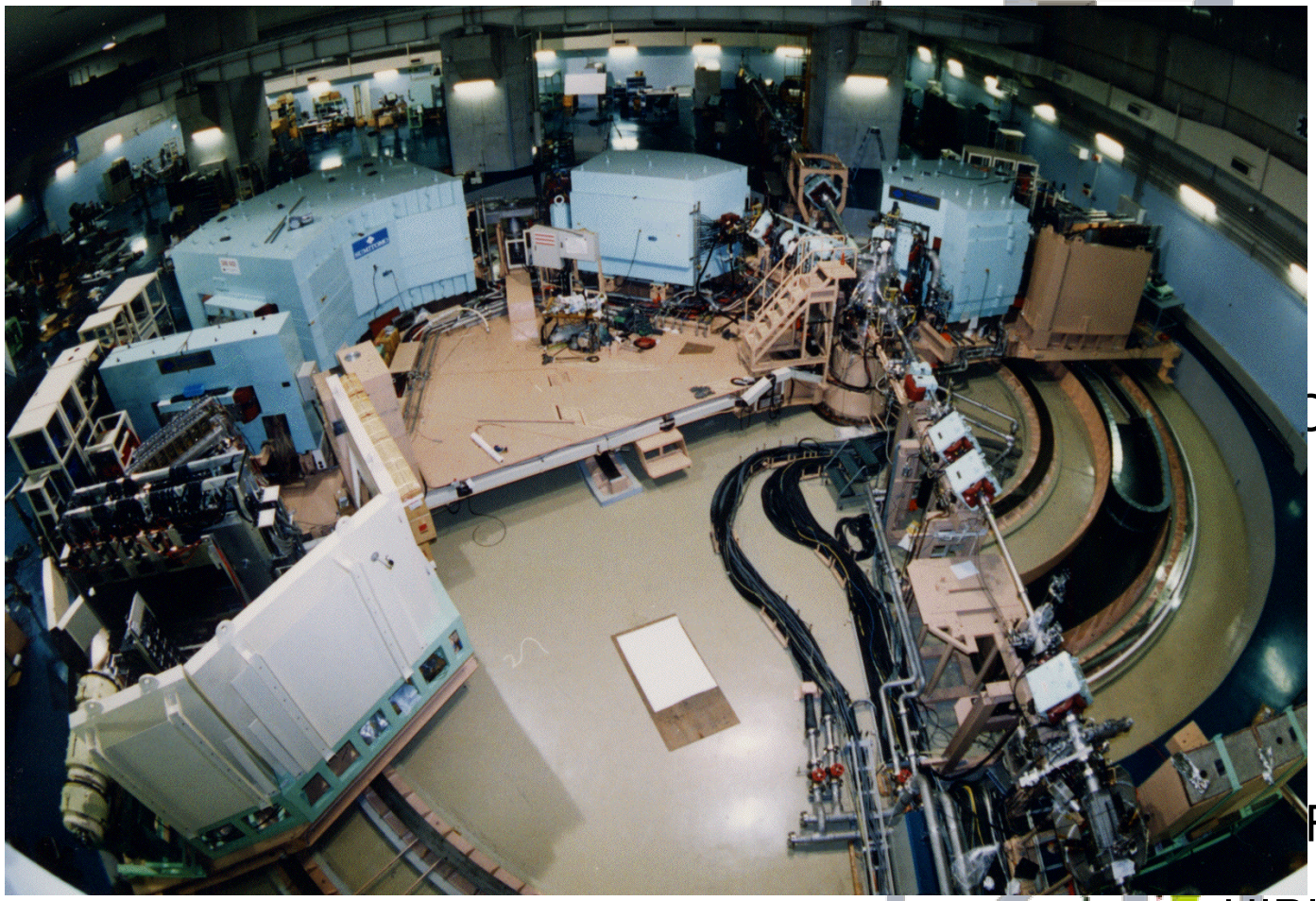
- E1 / M1 separation
  - selectivity on $\Delta L = 0$
  - Coulomb excitation
  - Coulomb-nuclear interference

- polarization observables at 0° →
- spinflip / non-spinflip separation

$$D_{SS} + D_{NN} + D_{LL} = \begin{cases} \text{-1 for } \Delta S = 1, \text{ M1 excitations} \\ \text{3 for } \Delta S = 0, \text{ E1 excitations} \end{cases}$$

- high resolution measurements needed

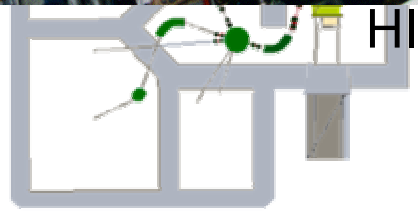
Cyclotron Facility at RCNP



Cyclotron

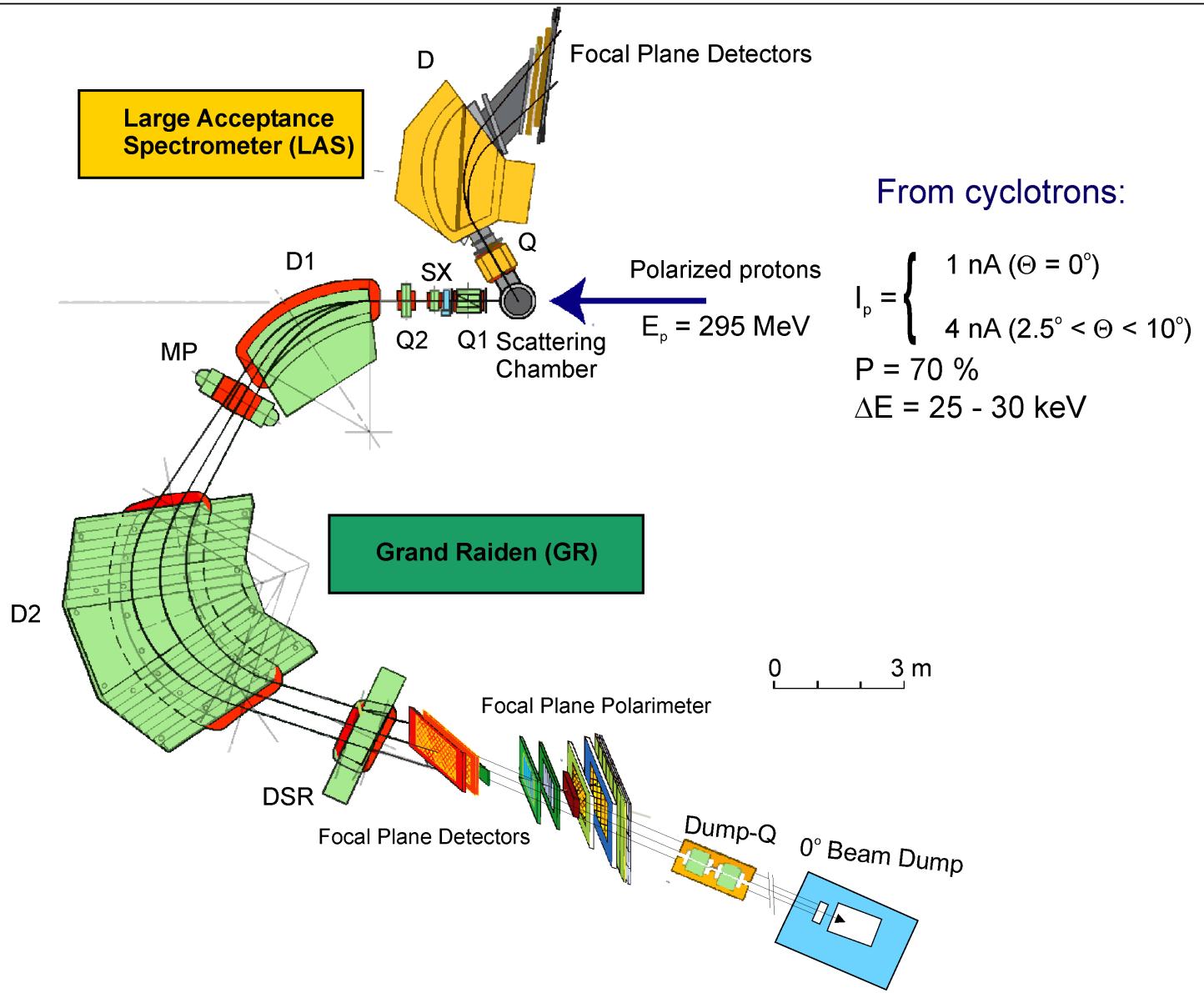
F

HIPIS



AVF Cyclotron Facility

0° Setup at RCNP



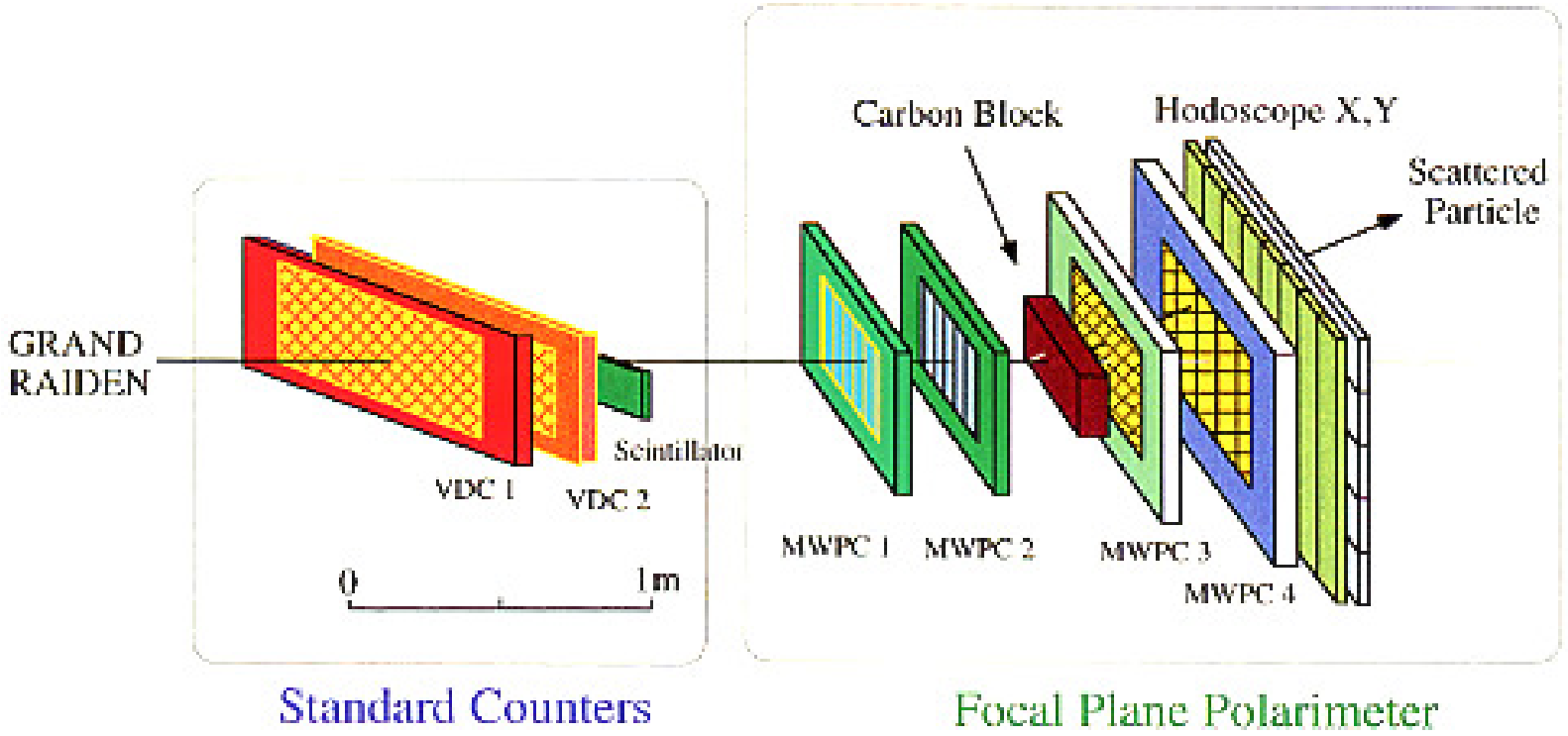
From cyclotrons:

$$I_p = \begin{cases} 1\ \text{nA}\ (\Theta = 0^\circ) \\ 4\ \text{nA}\ (2.5^\circ < \Theta < 10^\circ) \end{cases}$$

P = 70 %

ΔE = 25 - 30 keV

Focal Plane Detectors



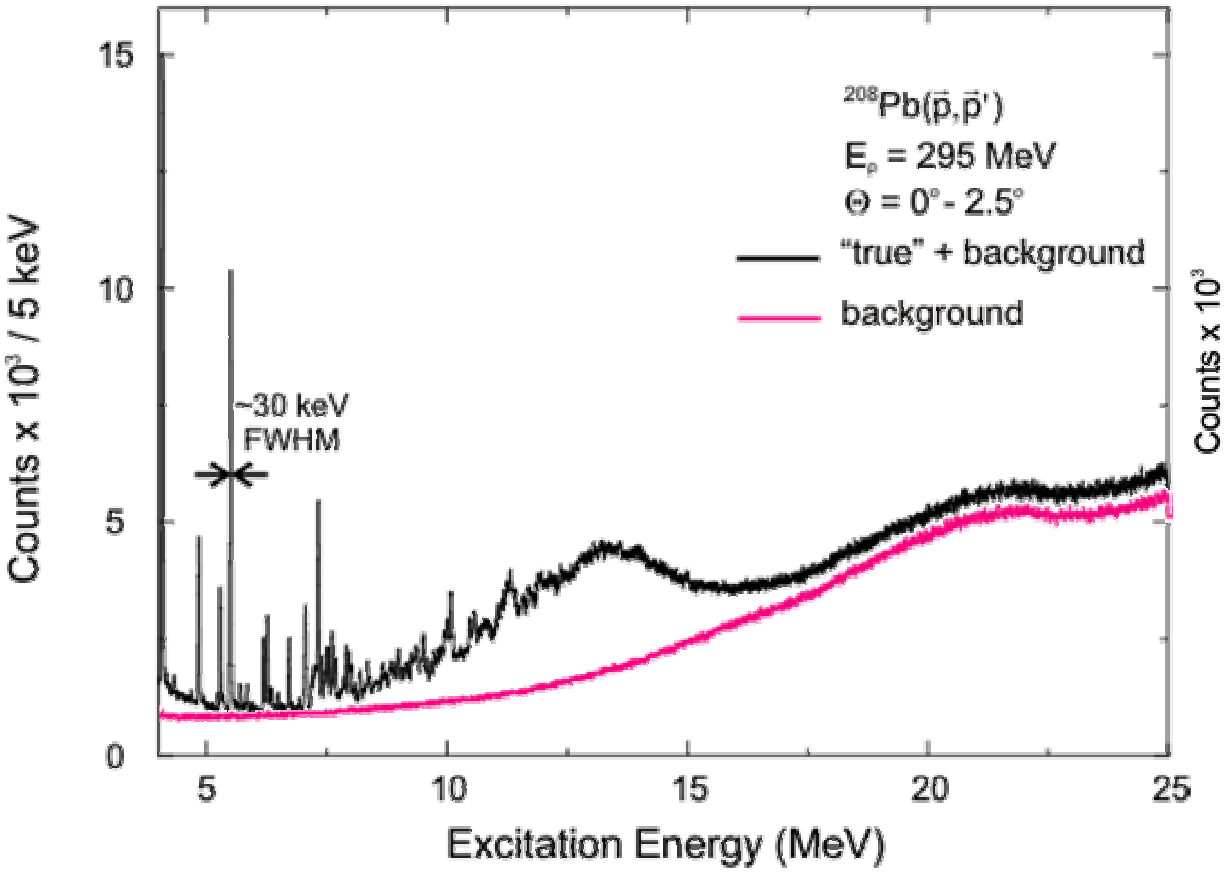
Measured polarization observables:

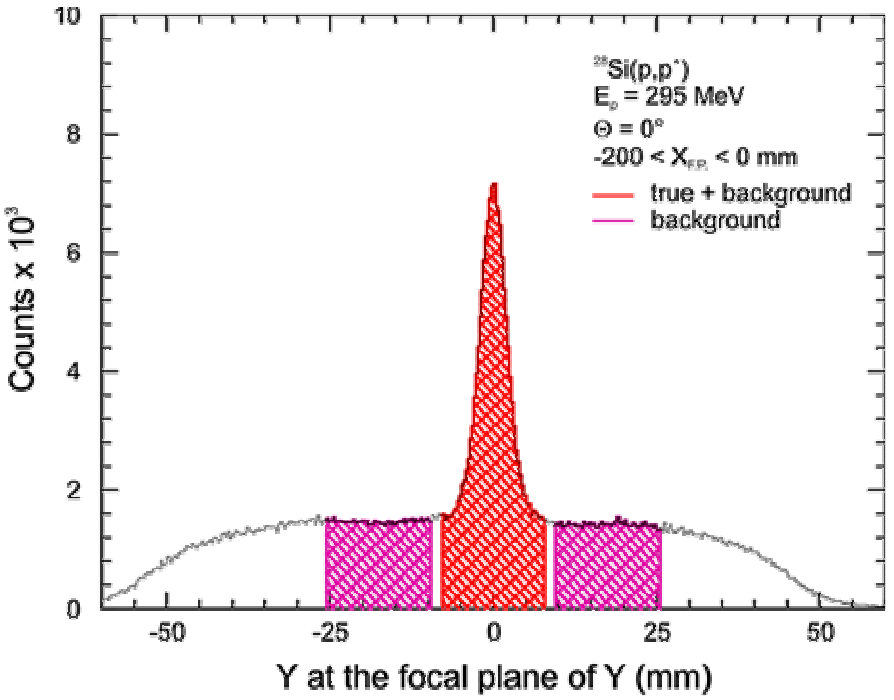
A_y - asymmetry

$D_{SS} = D_{NN}$ at 0° - sideway polarization transfer coefficient

D_{LL} at 0° - longitudinal polarization transfer coefficient

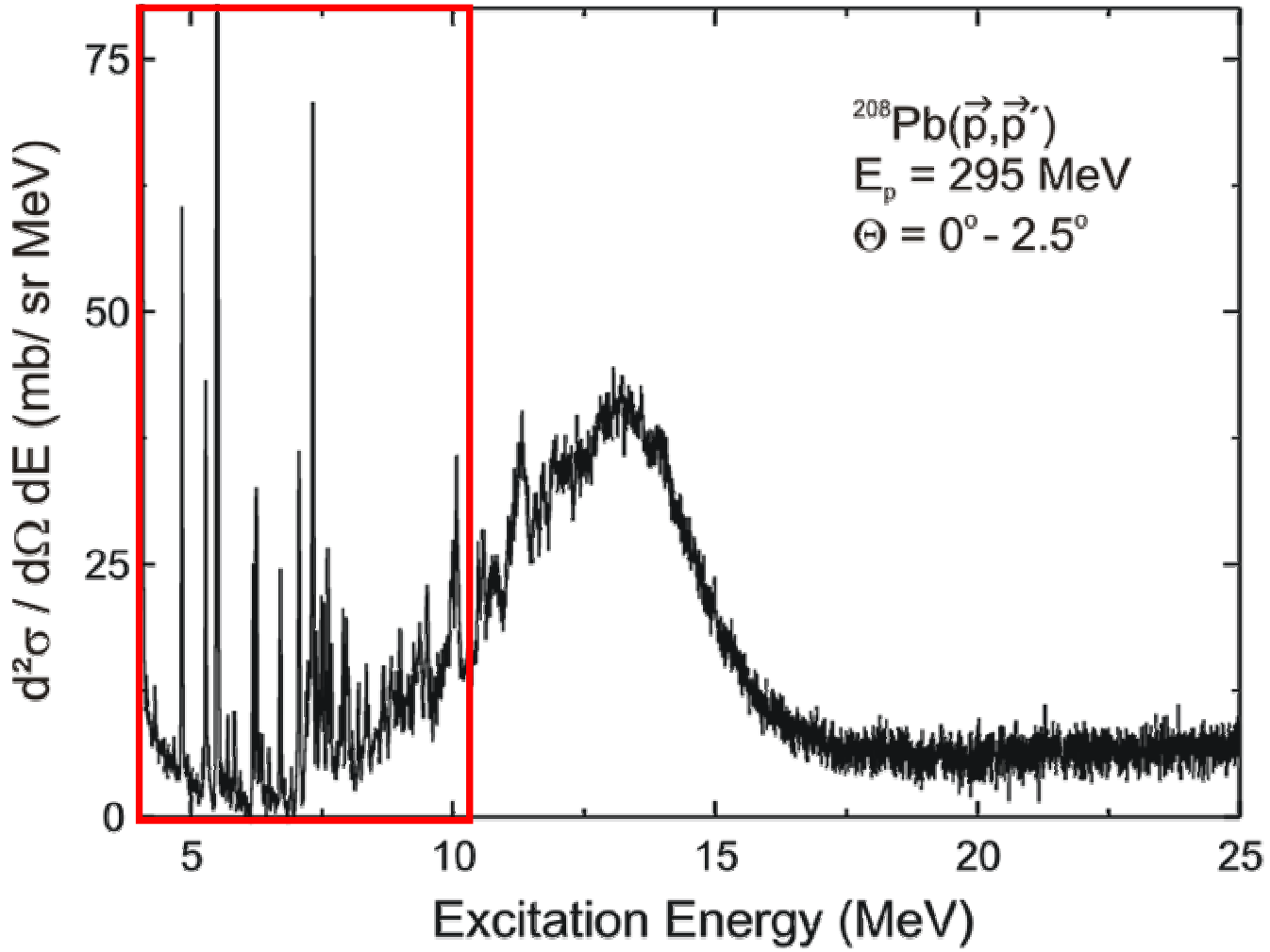
Measured Spectrum





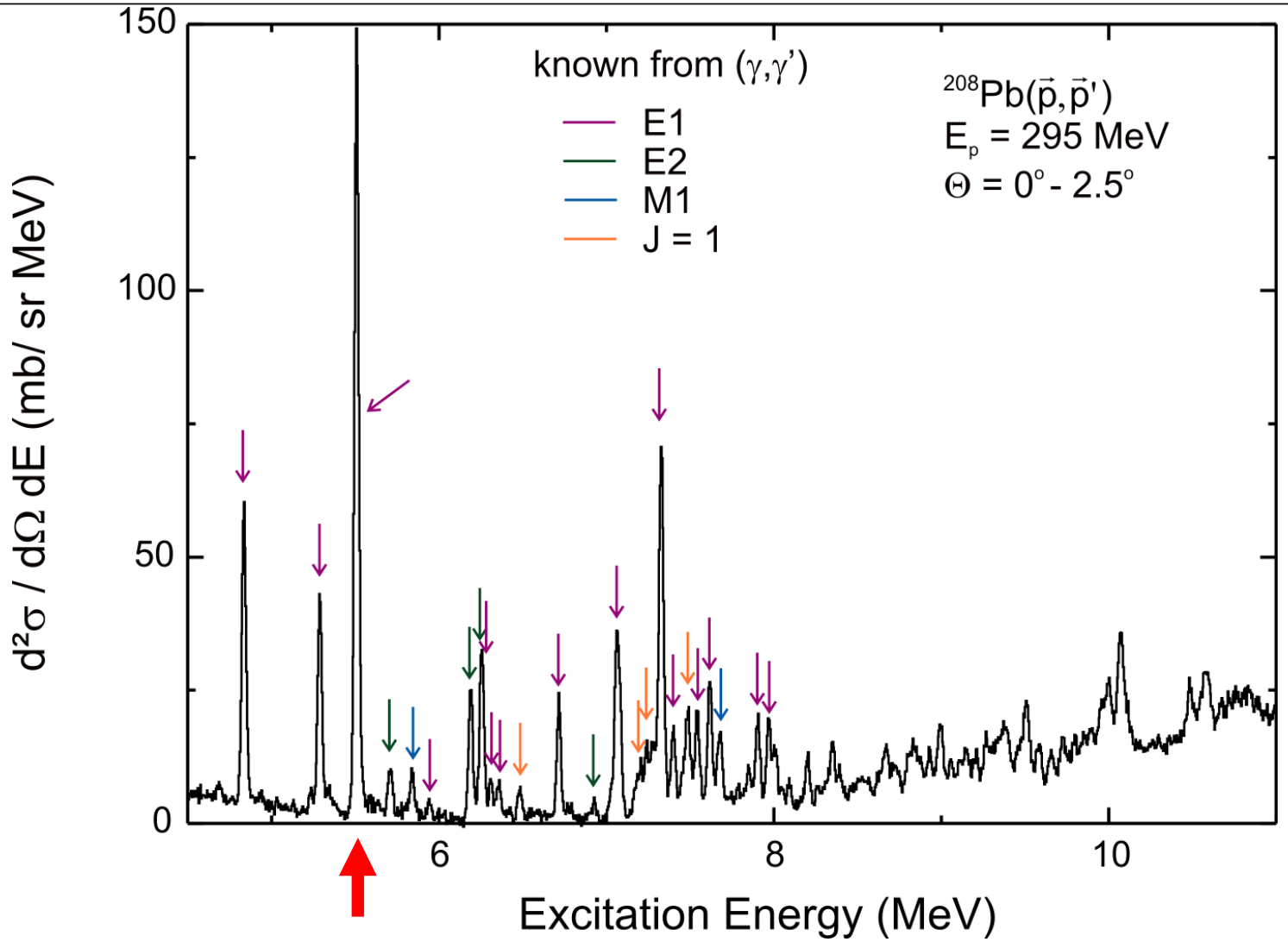
- mildly under-focusing mode in non-dispersive direction
- flat distribution of the background on the Y focal plane
- determines shape and magnitude of the background

Measured Spectrum
Background-Subtracted Spectrum



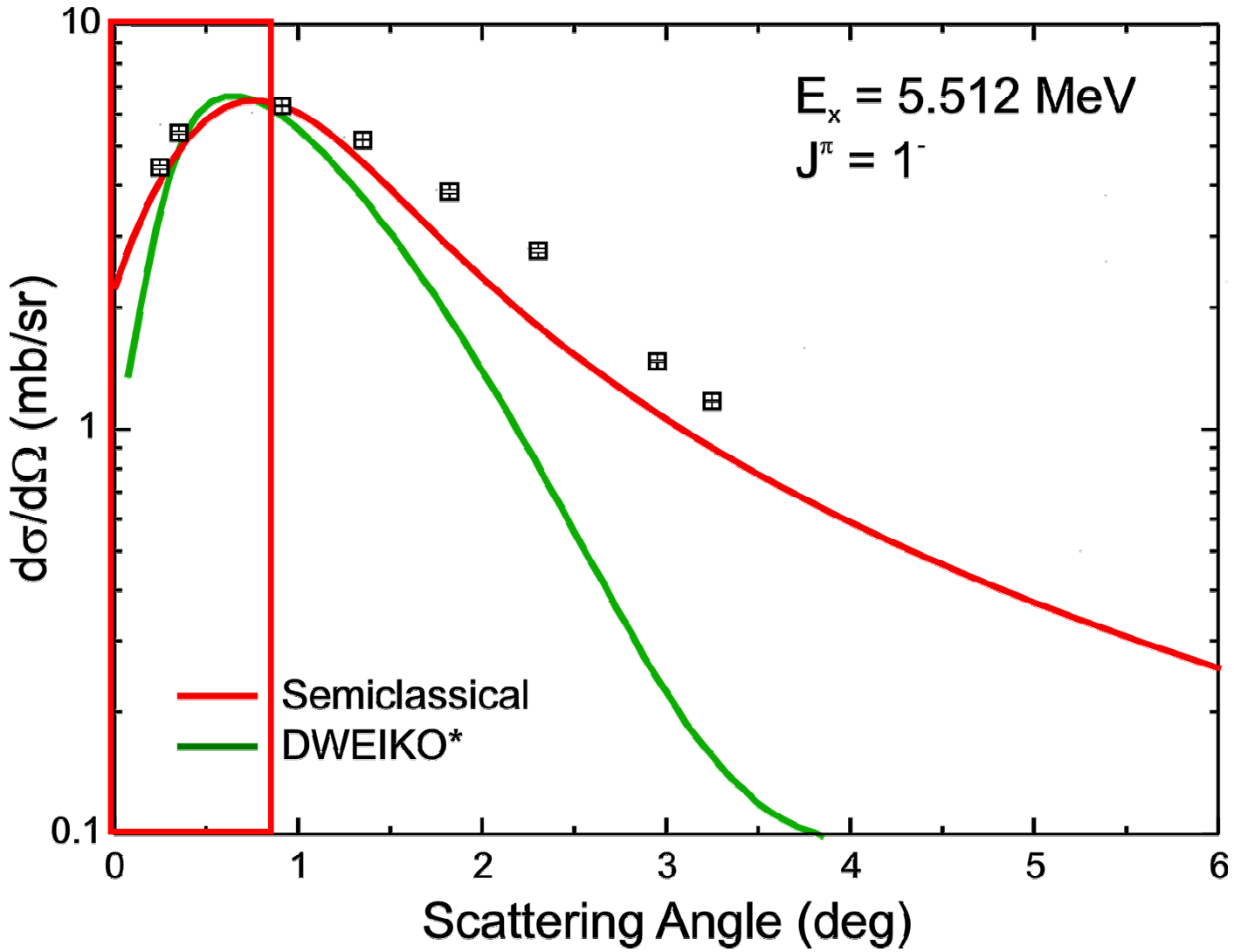
- Pronounced fine structure of the GDR is recognized
- Strong Coulomb excitation of the GDR at 0°

Measured Spectrum
Low-Energy Part



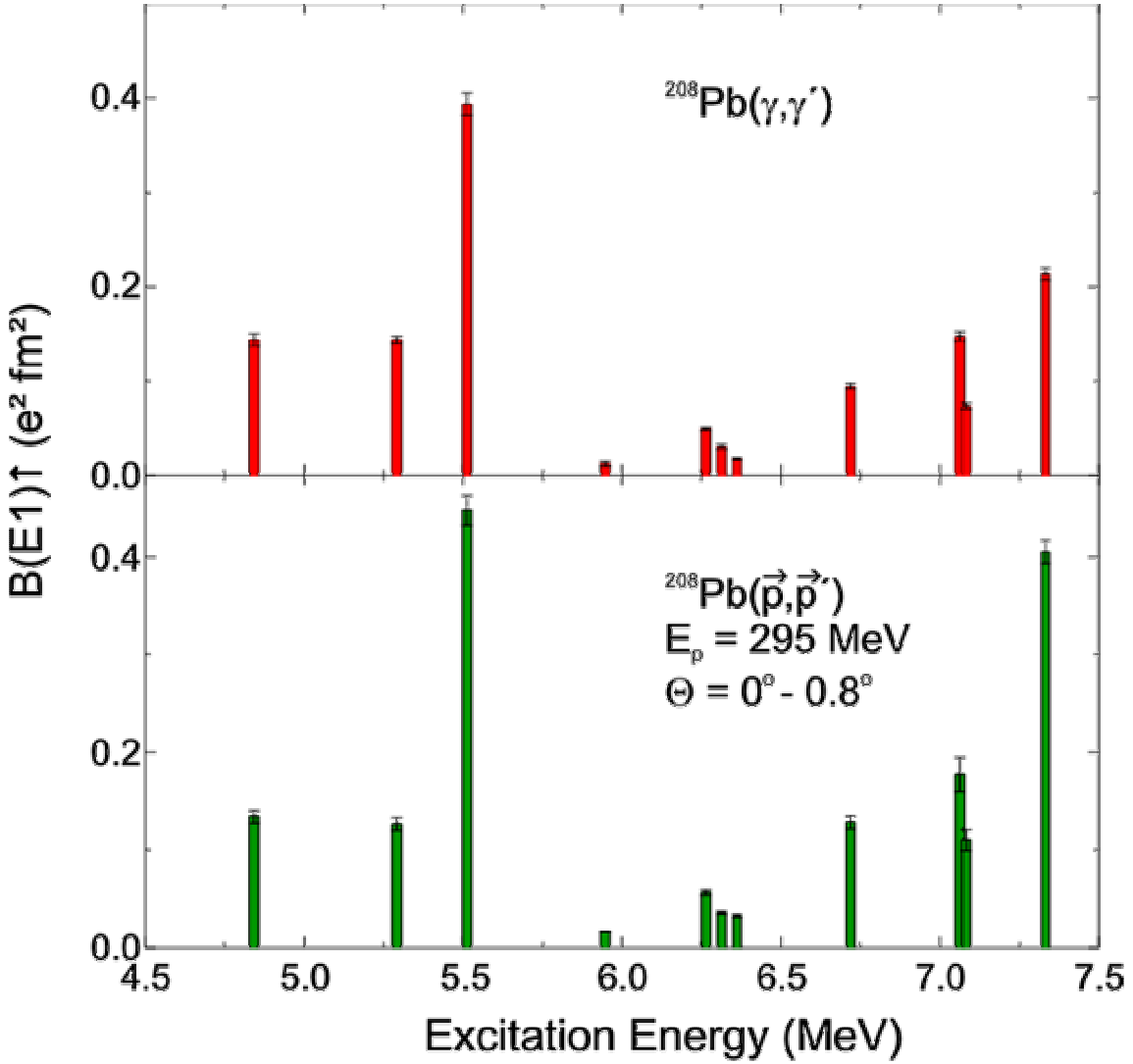
- All dipole transitions known from (γ,γ´) are observed

Coulomb Excitation of E1 Transitions

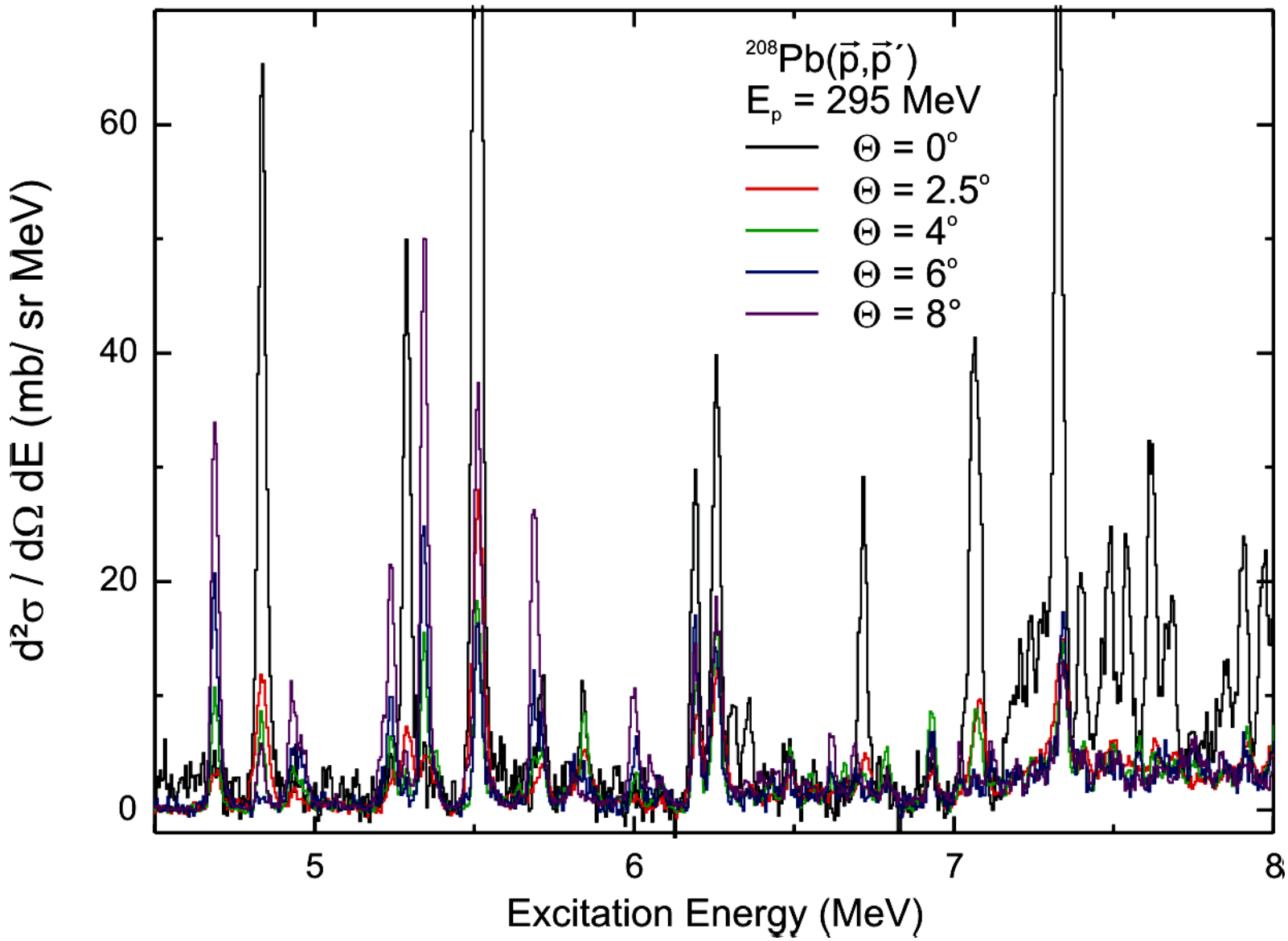


*C.A. Bertulani et al., Comp. Phys. Comm. 152 (2003) 317

Extracted Transition Strengths

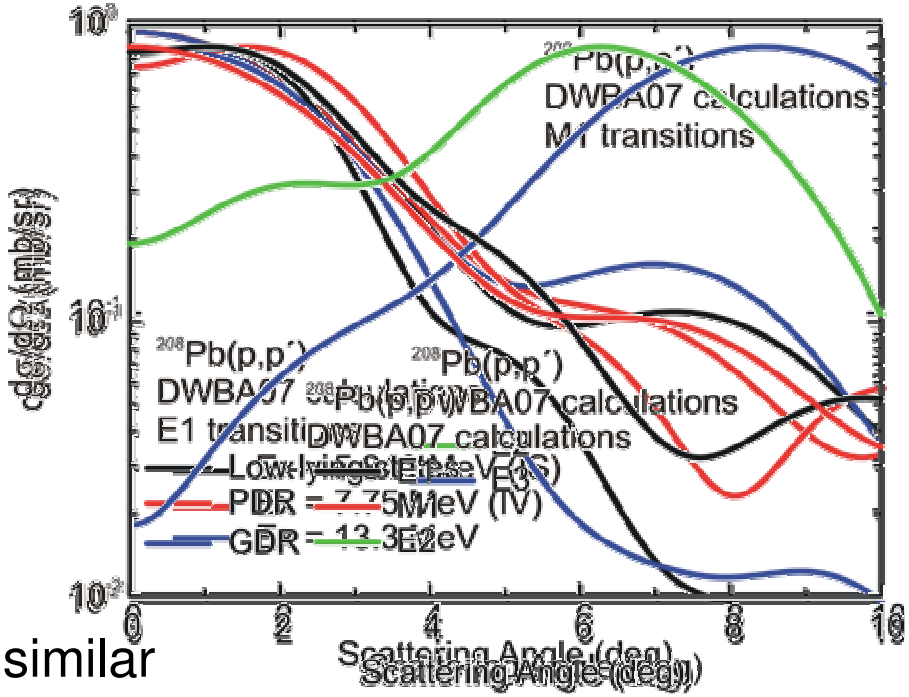


Spectra at Finite Angles



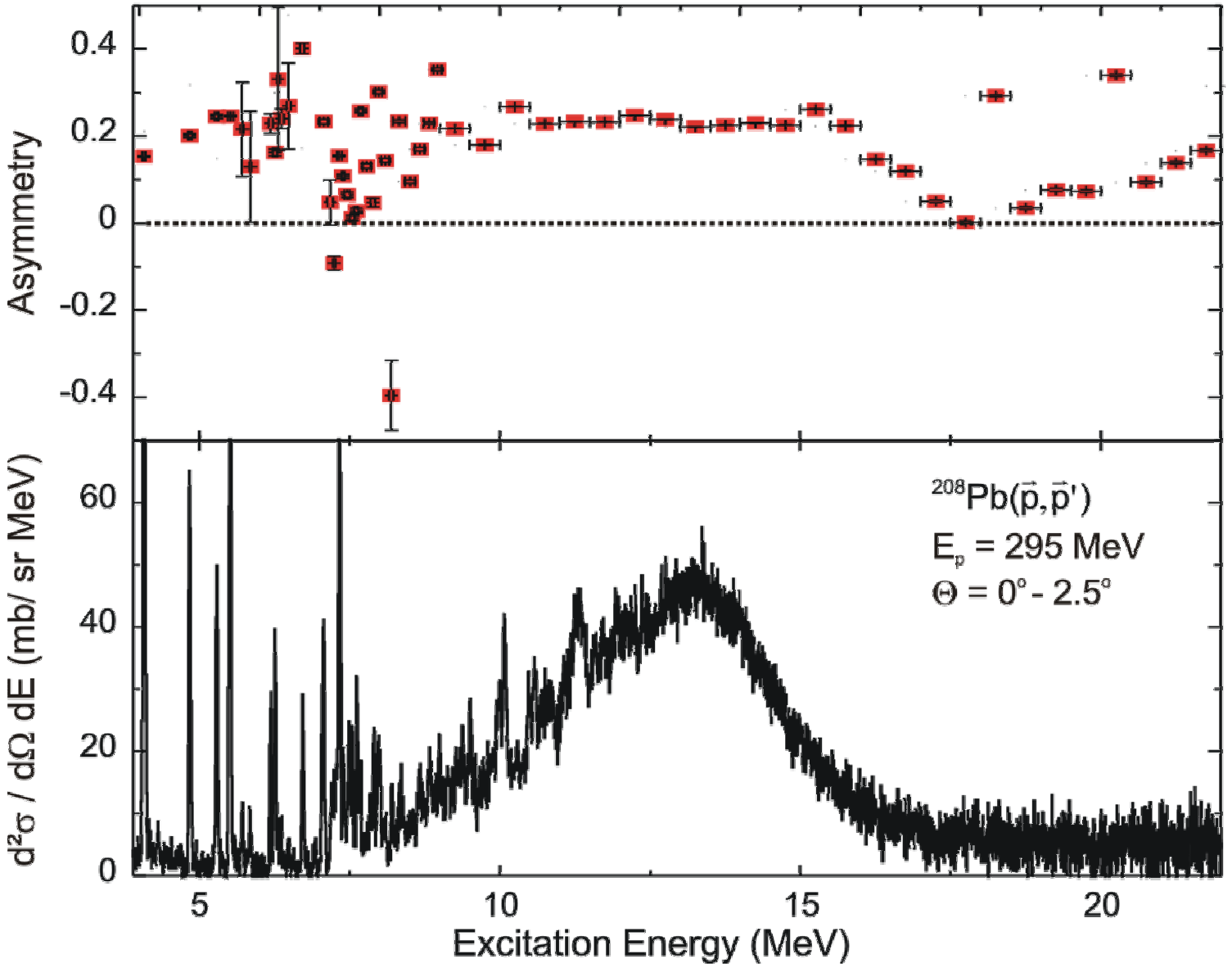
Multipole Decomposition

$$\left.\frac{d\sigma(\theta)}{d\Omega}\right|_{data} = \sum_{J^\pi} a_{J^\pi} \left.\frac{d\sigma(\theta)}{d\Omega}\right|_{DWBA}$$

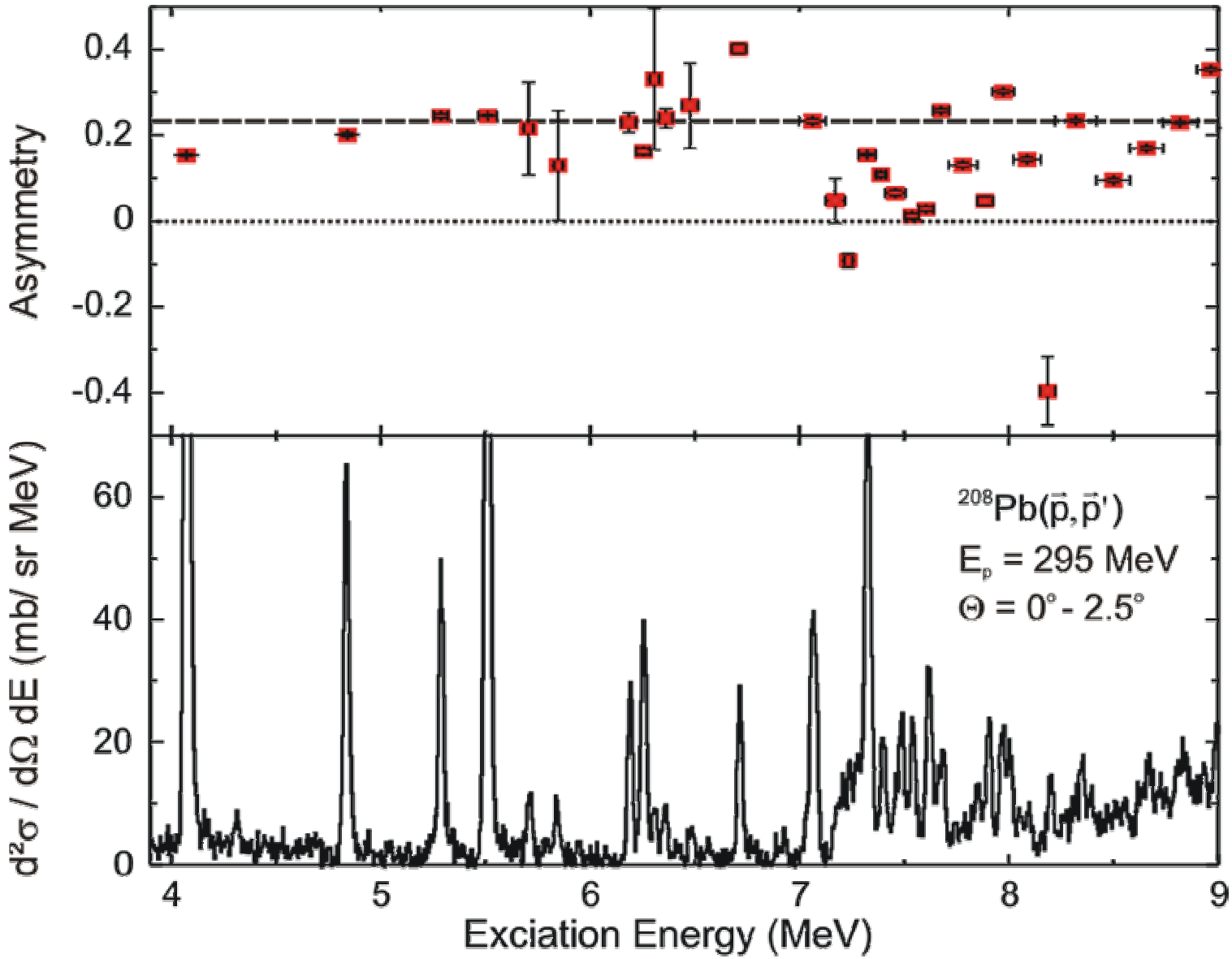


- Restrict angular distribution to 2.5° setting
- ΔL = 0
  - theoretical dσ/dΩ for IS and IV excitations are similar
- ΔL = 1
  - angular distribution averaged over individual levels
- ΔL = 2
  - substitute for all ΔL > 1

Experimental Asymmetry



Experimental Asymmetry
Low-Energy Part



Summary and Outlook

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- First high-resolution zero degree polarized proton scattering experiment on ^{208}Pb performed
- Measured observables: $d\sigma/d\Omega$, A_y, D_{SS}, D_{LL}
- Selective Coulomb excitation of 1^- states at very forward angles observed

- Multipole decomposition analysis
- Analysis of the polarization observables
- Investigation of the dipole strength in ^{120}Sn

Pygmy Dipole Resonance in ^{120}Sn
Measured Spectra

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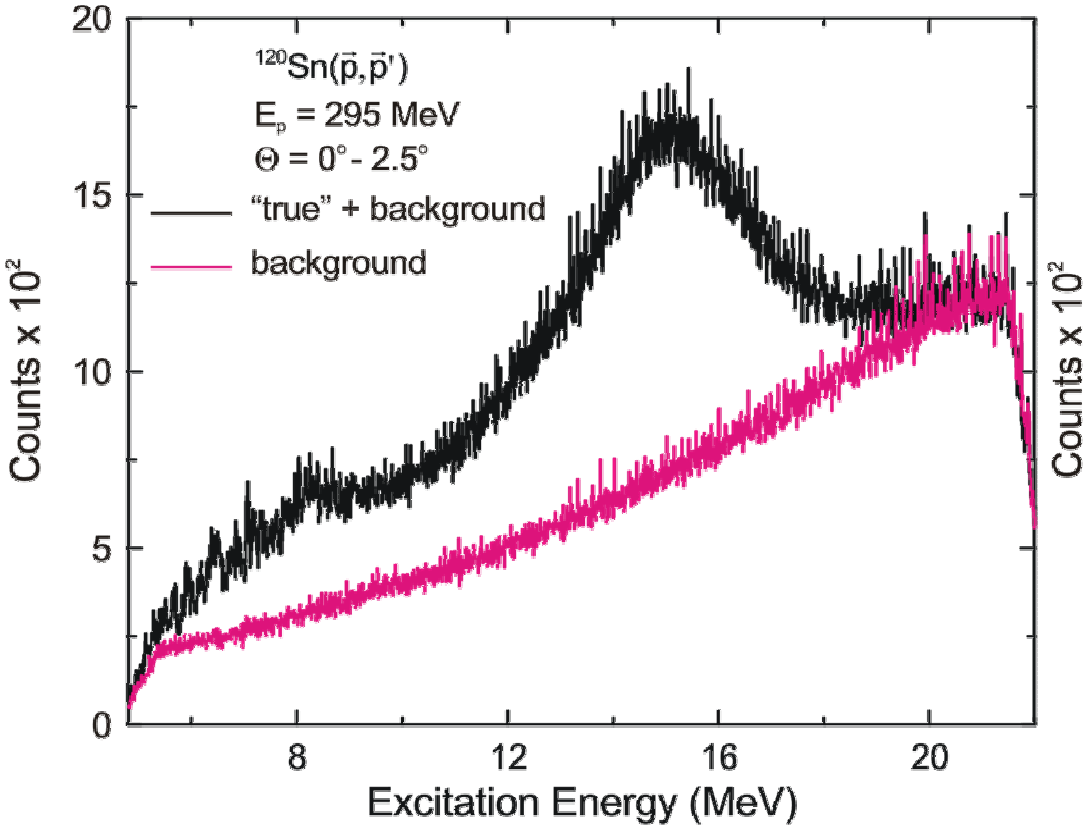
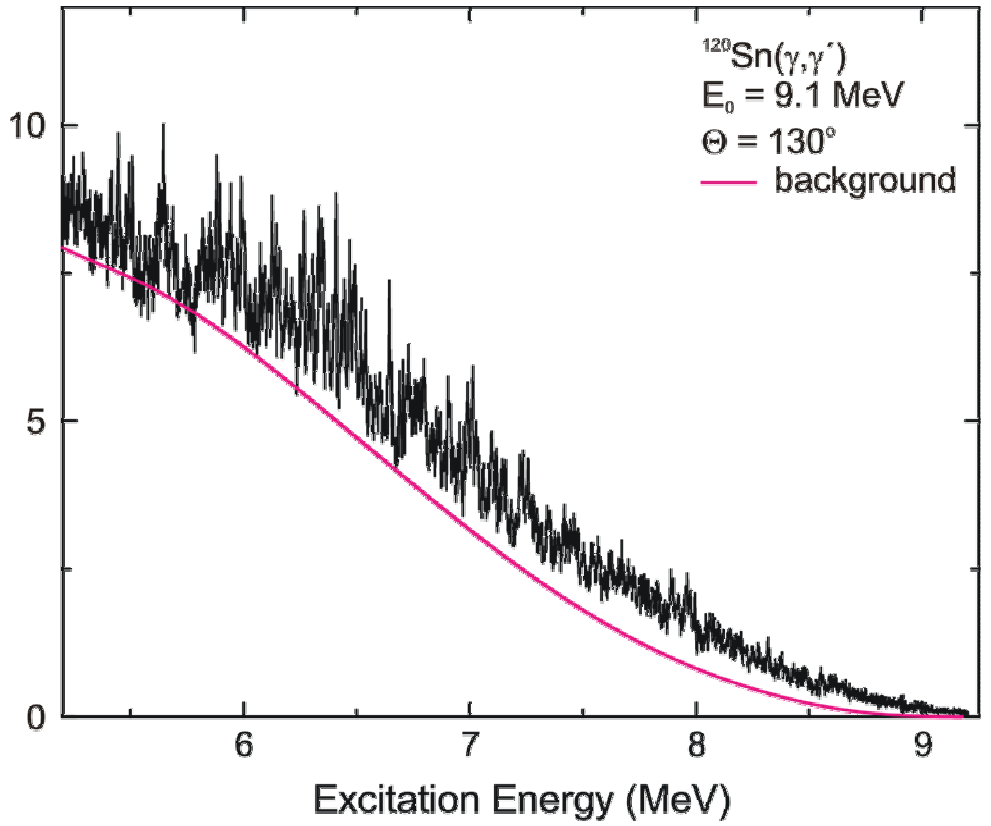
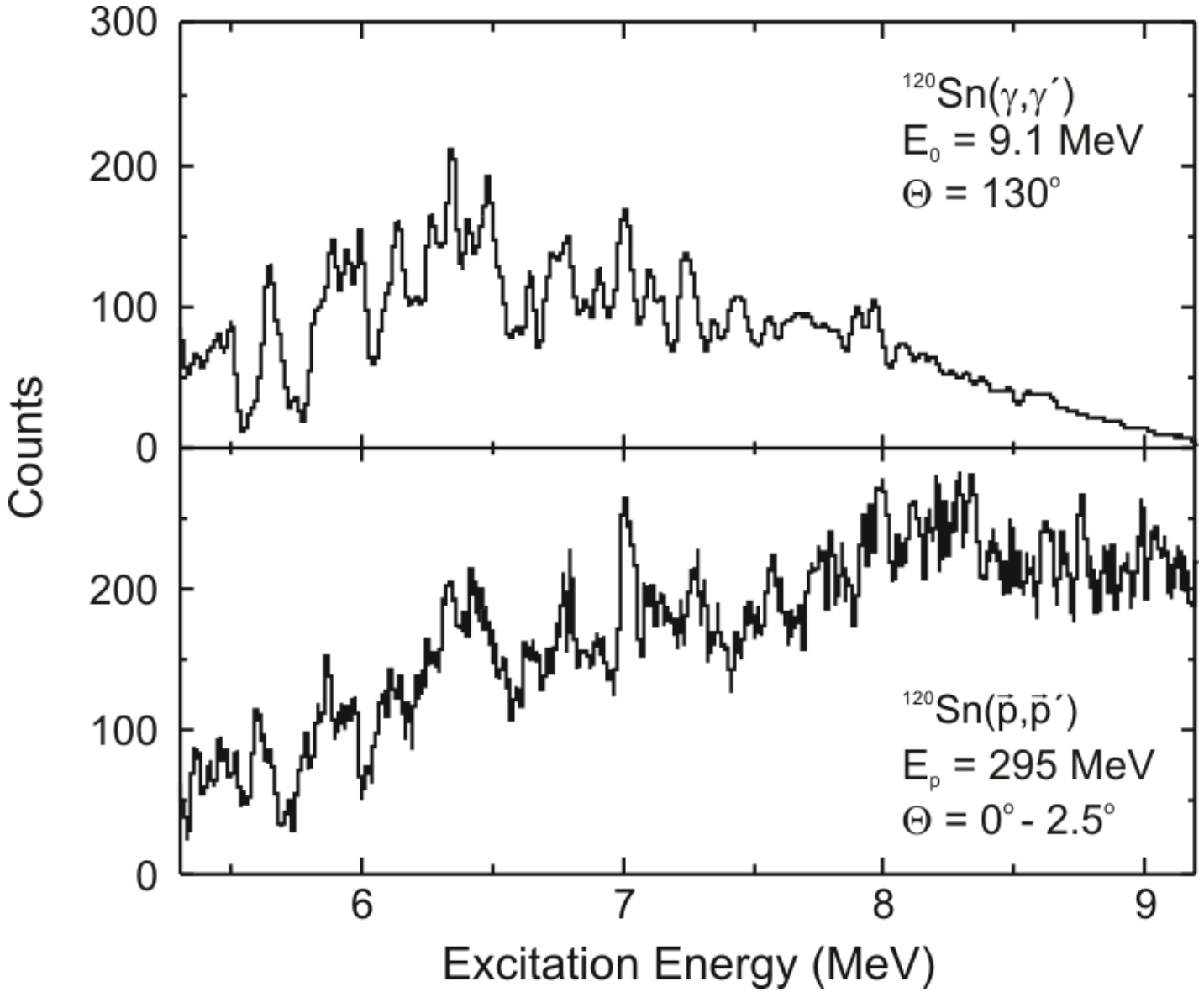




A. M. Heilmann, Poster, HK 67.6

B. Özel et al., PLB, submitted

Pygmy Dipole Resonance in ^{120}Sn
Measured Spectra II



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Thank you !!